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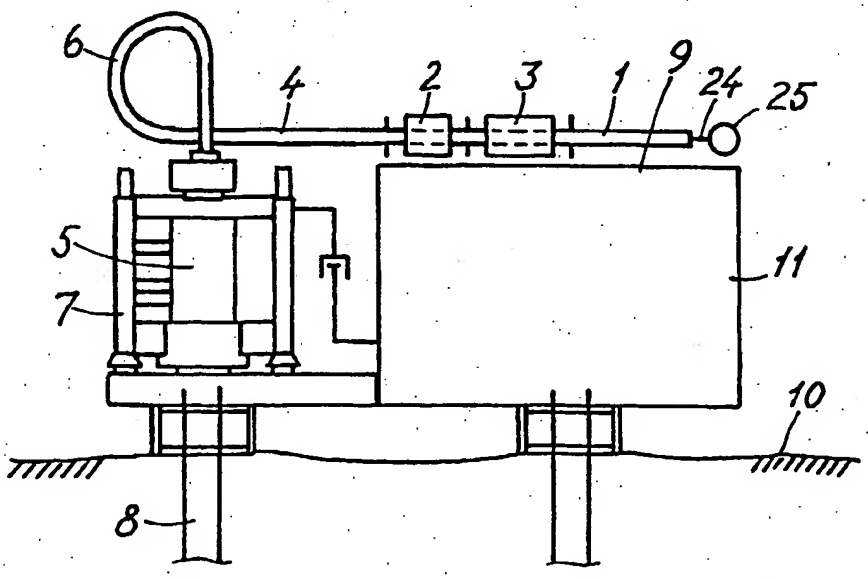
(54) Title: A SYSTEM FOR INTERVENTION OF SUBSEA WELLS



(57) Abstract: A system for intervention of subsea wells, comprising a lubricator (1) coupled to a diverter unit (2), and a well tractor unit (12) accommodated in the lubricator (1) and being arranged to carry service of repair components into or up from the relevant well via the diverter unit (2). The lubricator (1) and the diverter unit (2) are arranged on a foundation (9) at the seabed (10), with the diverter unit (2) connected via respective branch pipes (4) to the relevant wells, and between the lubricator (1) and the diverter unit (2) there is arranged a magazine (3) which is arranged to receive the relevant service or repair components, so that these can be transferred from the magazine to the well, or vice versa, by means of the tractor unit (12).

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A system for intervention of subsea wells

The invention relates to a system for intervention of subsea wells, comprising a lubricator coupled to a diverter unit, and a well tractor unit accommodated in the lubricator and being arranged to carry service and repair components into or up from the relevant well via the diverter unit.

In the intervention of subsea wells there have previously been used different techniques, viz. so-called TFL service (TFL = Through Flowline) or pump-down service, wireline service or coiled tubing service.

TFL service implies that the relevant tools or components are pumped into the subsea wells from a pump station situated on a surface facility, usually a surface vessel. As soon as the task is completed, the tool or the replaceable component is pumped out again.

Wireline service implies that the tool for information seeking or maintenance is run into the well on a wire. As surface facility is needed above the subsea wells. This can be a drilling vessel or a specialised ship.

When using coiled tubing, this has two different tasks. Firstly, it is a small diameter tubing that can be run into a well for accurate placement of chemicals in the well. Secondly, the coiled tubing is used to carry tools into the well where a wireline can not go, i.e. in horizontal sections or in sections of a well having a strong deviation from the vertical. A surface facility is required for this work, e.g. a drilling vessel or a specialised ship.

The methods mentioned above are encumbered with different drawbacks and deficiencies.

As regards the TFL method, this has a limited distance from which the pump-down can be operated, and thus limits the distance at which satellite wells can be located from the platform. Both the other methods are based on costly surface facilities and reasonably good weather to complete the well maintenance tasks.

Thus, the currently used methods for maintenance or "tuning" of subsea wells are based on a drilling vessel, e.g. a semi-submersible vessel, or a specialised ship being brought over the subsea well. The costs of doing subsea well intervention mean that only repairs are done, not reservoir information seeking, such as routinely done with platform wells. This has the practical consequence that the oil production/recovery from a platform well will be better than for a subsea well.

On this background it is an object of the invention to provide a system enabling remote intervention of subsea wells without the use of costly surface facilities.

Another object of the invention is to provide such a system wherein the well intervention is controlled via the umbilical of the production control system.

Additional objects of the invention are to provide such a system enabling service on multi-wells, and enabling the execution of a variety of tasks in any well linked to the system.

The above-mentioned objects are achieved with a system of the introductorily stated type which, according to the invention, is characterised in that the lubricator and the diverter unit are arranged on a foundation at the seabed, with the diverter unit connected via respective branch pipes to the relevant wells, a magazine being provided between the lubricator and the diverter unit, which magazine is arranged to receive the relevant service or repair components, so that these can be transferred from the magazine to the well, or vica versa, by means of the tractor unit.

By means of the invention there is provided a subsea well intervention system which does not require any surface facility, neither a drilling rig nor a specialised ship. Further, one is not dependent on a weather window for the intervention operation, because a surface vessel is not part of the operation.

A possible retrieval of the components of the system to the surface can be undertaken with non-well intervention techniques. These can be carried out at a price of 5-10% of the cost of a well intervention. All components can weigh less than 5 tons and be less than 4 meters long. This will ensure that a suitable vessel can effect retrieval and replacement "over the side", and a "moonpool" vessel will not be required.

The system implies that more complicated subsea wells can be planned. Reservoir control can be enhanced because of the availability of non-expensive well intervention technology. Subsea wells therefore ought to approach the capability of platform wells in terms of reservoir productivity.

The invention will be further described below in connection with an exemplary embodiment with reference to the drawings, wherein

Fig. 1 shows a schematic view of a system according to the invention;

Fig. 2 shows a schematic perspective view of an embodiment of a magazine in the system according to the invention; and

Fig. 3 shows a schematic perspective view of a diverter unit in the system according to the invention.

As appears from Fig. 1, the system according to the invention comprises a so-called lubricator 1 which is coupled to a diverter unit 2 via a magazine 3, wherein the diverter unit 2 comprises or is coupled to a number of branch pipes 4 (only one is shown) of which each branch pipe communicates with a respective subsea well (not shown). The branch pipe 4 is shown to be connected to a Christmas tree 5 via a pipe loop 6 for vertical access to a well communicating with a wellhead 7 - of which the Christmas tree 5 forms a part - via a partly shown well pipe 8.

The series connection of lubricator 1, magazine 3 and diverter unit 2 is arranged on a foundation 9, e.g. a template, located at the seabed 10. In the illustrated embodiment the foundation is constituted by a horizontal upper surface of a manifold 11 which is connected to the relevant subsea wells. Said series connection is shown to be arranged in a horizontal arrangement on the horizontal surface, so that the building height of the system is very small. In order to reduce the building height further, the branch pipes 4 may be connected to the Christmas tree 5 in question via a bent pipe section instead of the illustrated pipe loop 6.

The magazine 3 is arranged to receive service, repair and replacement components, together with logging and repair tools, which are intended for or are to be used in the relevant well or wells, so that these components can be transferred from the magazine to the relevant well, or vice versa, by means of a well tractor unit 12 (see Fig. 2) which is contained in the lubricator 1 and is arranged to bring the relevant components into or up from the well via the diverter unit.

An embodiment of the magazine 3 is shown in Fig. 2. In this embodiment the magazine resembles a six-gun magazine of a pistol and comprises a rotatable, cylindrical container 13 containing a number of axial paths or passages 14 arranged at the periphery. Each of these passages is adapted to receive the relevant components, and by rotation of the container may be brought into simultaneous connection with the lubricator 1 and with the diverter unit 2. For rotation of the container 13 to the desired position, the container in the illustrated embodiment is provided with a peripheral gear rim 15 which is in engagement with a driving cogwheel rotated by a hydraulic motor 16. Alternatively, there may be used a stepping actuator in cooperation with the gear rim.

As it will be clear, the magazine may be designed in many different ways. For example, instead of a rotating magazine, there may be used a magazine which can be moved from side to side, to allow access to a desired one of its passages or bores.

An embodiment of the diverter unit 2, which is of a type known per se, is shown in Fig. 3. As appears, the diverter comprises a container 17 which, at one end surface thereof, is coupled to a central pipe 18 coming from the magazine 3, and at its other end surface is coupled to a number of transition pipes 19 which, via a multi-bore connector 20, are coupled to respective ones of the relevant branch pipes 4 leading to the Christmas trees 5 on the wellheads for the respective wells. Within the container 17 there is arranged a guide tube 21 which, at one end thereof, is rotatably coupled to the central pipe 18, and which is inclined or angled relative to the longitudinal axis of the container 17, so that its other end may be connected to a desired one of the transition pipes 19, by being rotated by means of a suitable, e.g. hydraulically driven, positioning device (not shown).

In order to be able to stand the relevant well pressure, the diverter container is designed as a pressure vessel. For the same purpose, also the magazine container 13 is designed as a pressure vessel.

As appears from Figs. 2 and 3, the lubricator 1 and the magazine 3 are interconnected via a single-bore connector 22, and the magazine and the diverter unit 2 are interconnected via a single-bore connector 23. Both the pressure vessels 13, 17 and the connectors 22, 23 are remotely operated, with a view to for example remotely controlled connection and disconnection of the elements.

The internal diameter of the pipe components of the system, including the lubricator 1, will be essentially the same as the diameter of the well tubing.

As regards the tractor unit 12, this is a commercially available unit. The unit is self-powered, so that it can move into and out of the well, and it has suitable dimensions to be received in and housed by the lubricator when it is not in activity. The tractor unit is constructed to carry out many different tasks in subsea wells. Among these there may be mentioned

- placement and retrieval of pressure and temperature measurement instruments,
- retrieval and replacement of well safety valves,
- retrieval and replacement of gas lift valves,
- placing and replacement of plugs,
- retrieval and replacement of so-called "scrams" valves,
- operation of sliding sleeve devices.

The tractor unit 12 normally is arranged to be powered by batteries. Further, it may be connected to an electric cable for power supply or for recharging of the batteries, and/or to receive programming for the relevant tasks. This cable then will be connected to the production control system for the well or wells. In Fig. 1 there is suggested such a cable 24 which is coupled to a winch 25.

When well intervention is to be carried out with the system according to the invention, the magazine 3 firstly is placed in the appropriate position for the task. If it is the question of a replacement of a valve, the appropriate position may be an empty passage or bore 14 in the magazine. The tractor unit 12 then moves through the empty bore in the magazine 3, into the diverter unit 2 which is set for the relevant well, and through the possible pipe loop 6 and into the well. The tractor unit fetches the destroyed valve in the well, goes back and deposits the valve in the magazine, and goes back and into the lubricator. The magazine thereafter is repositioned to place a new valve in the correct position for the tractor in the lubricator. The tractor is reprogrammed to install the new valve, and this is done in a similar manner as retrieving the broken valve.

Patent claims

1. A system for intervention of subsea wells, comprising a lubricator (1) coupled to a diverter unit (2), and a well tractor unit (12) accomodated in the lubricator (1) and being arranged to carry service or repair components into or up from the relevant well via the diverter unit (2), **characterised in** that the lubricator (1) and the diverter unit (2) are arranged on a foundation (9) at the seabed (10) with the diverter unit (2) connected via respective branch pipes (4) to the relevant wells, a magazine (3) being provided between the lubricator (1) and the diverter unit (2), which magazine (3) is arranged to receive the relevant service or repair components, so that these can be transferred from the magazine to the well, or vice versa, by means of the tractor unit (12).

2. A system according to claim 1, **characterised in** that the lubricator (1), the magazine (3) and the diverter unit (2) are arranged in a horizontal arrangement on the foundation (9).

3. A system according to claim 2, **characterised in** that the foundation is constituted by the upper side of a manifold (11) at the seabed (10).

4. A system according to one of the claims 1-3, **characterised in** that the magazine (3) comprises a rotatable, cylindrical container (13) containing a number of axial passages (14) arranged along the periphery, each of the passages (14) by rotation of the container (13) being able to be brought into simultaneous connection with the lubricator (1) and with the diverter unit (2).

5. A system according to claim 4, **characterised in** that the container (13) is provided with a peripheral gear rim (15) which is in engagement with a driving cogwheel rotated by a hydraulic motor (16), for rotation of the container (13) to the desired position.

6. A system according to one of the preceding claims, **characterised in** that the magazine (3) is arranged within a remotely operable pressure vessel (13).

7. A system according to one of the preceding claims, **characterised in** that the tractor unit (12) is coupled to an electric cable (24) for control of and power supply to the tractor unit, the cable (4) being connected to a subsea control system.

8. A system according to one of the claims 1-6, **characterised in** that the tractor unit (12) is arranged to be powered by batteries.

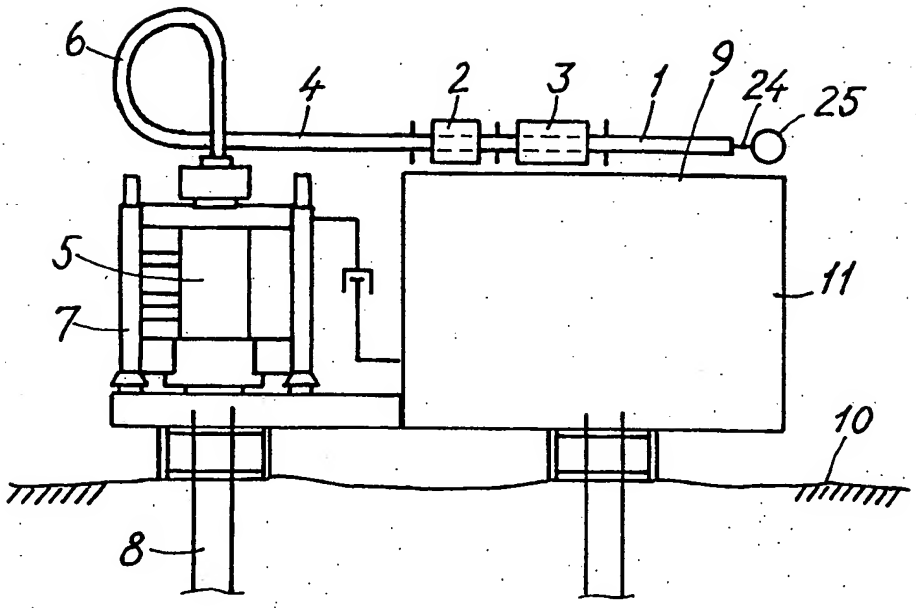

FIG. 1

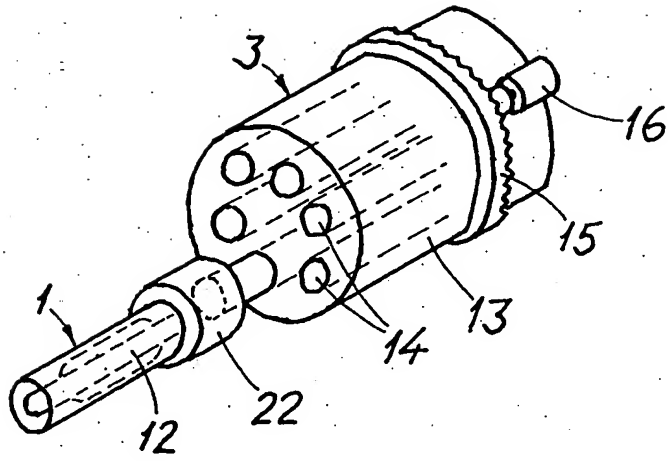

FIG. 2

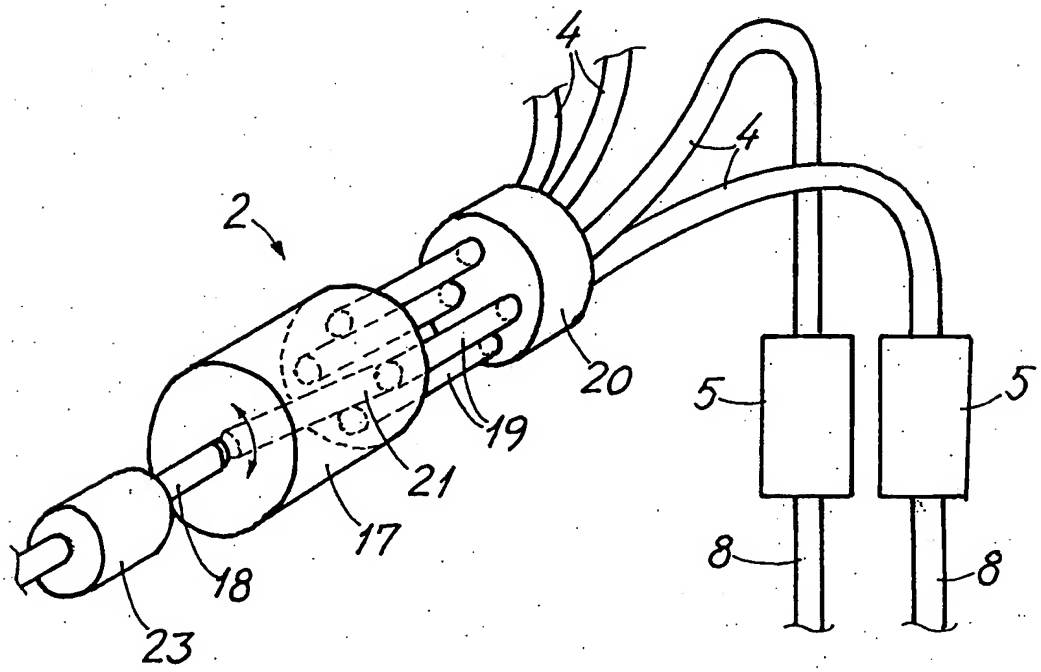

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 00/00446

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: E21B 23/00, E21B 33/064
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 0003112 A1 (FMC CORPORATION), 20 January 2000 (20.01.00) --	1-8
A	GB 2326433 A (FMC CORPORATION), 23 December 1998 (23.12.98) --	1-8
A	GB 2299108 A (DEN NORSKE STATS OLJESELSKAP A.S.), 25 Sept 1996 (25.09.96) --	1-8
A	US 3877520 A (P.S. PUTNAM), 15 April 1975 (15.04.75) -- --------	1-8

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
4 April 2001	06 -04- 2001
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Christer Bäcknert / MRo Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

25/02/01

International application No.
PCT/NO 00/00446

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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